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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/665,998	09/17/2003	Gregory P. Schaadt	P117-US	6605

26148 7590 02/18/2005

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EXAMINER	
CHEN, ERIC BRICE	
ART UNIT	**PAPER NUMBER**
1765	

DATE MAILED: 02/18/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/665,998	Applicant(s) SCHAADT ET AL.	
	Examiner Eric B. Chen	Art Unit 1765	

-- *The MAILING DATE of this communication appears on the cover sheet with the correspondence address* --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 1/14/05.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-97 is/are pending in the application.

4a) Of the above claim(s) 92-97 is/are withdrawn from consideration.

5)☒ Claim(s) 72-91 is/are allowed.

6)☒ Claim(s) 1-71 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date 9/17/03;10/12/04.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

DETAILED ACTION

Election/Restrictions

1. Applicant's election of Invention I (claims 1-91) in the reply filed on Jan. 14, 2005 is acknowledged. Because applicant did not distinctly and specifically point out the supposed errors in the restriction requirement, the election has been treated as an election without traverse (MPEP § 818.03(a)).

Priority

2. Applicant is advised of possible benefits under 35 U.S.C. 119(a)-(d), wherein an application for patent filed in the United States may be entitled to the benefit of the filing date of a prior application filed in a foreign country.

Specification

3. The use of the trademarks MKS and AMETEK has been noted in this application (paragraph 0026). It should be capitalized wherever it appears and be accompanied by the generic terminology. Although the use of trademarks is permissible in patent applications, the proprietary nature of the marks should be respected and every effort made to prevent their use in any manner which might adversely affect their validity as trademarks.

Claim Objections

4. Claims 27 and 58 are objected to because of the following informalities: as to the temperature of the second chamber, "25°" should apparently be -- 25°C --. Appropriate correction is required.

Claim Rejections - 35 USC § 102

5. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

6. Claims 1-4, 7-8, 15, 21, 24-27, 35-38, 43-45, 49, 52, and 55-58 are rejected under 35 U.S.C. 102(b) as being anticipated by Tai et al. (U.S. Patent No. 6,162,367).

7. As to claim 1, Tai discloses a method, comprising: loading a microstructure (column 6, lines 59-60) into an etch chamber (110) (column 6, line 29), wherein the microstructure comprises a sacrificial material (column 6, lines 64-67) and one or more structural materials (column 6, line 29); and providing a first discrete amount of spontaneous vapor phase etchant recipe (column 5, lines 42-45) during a first feeding cycle of a sequence of feeding cycles for removing the sacrificial material (column 5, lines 56-67; column 6, lines 1-5; Figure 1B). Although Tai does not expressly disclose the step of: providing a second discrete amount of the etchant recipe after the first feeding cycle and during a second feeding cycle that follows the first feeding cycle of the sequence of feeding cycles for removing the sacrificial materials, this step is

inherently present in Tai's method. Tai discloses that the amount of etchant gas is pulsed (column 6, lines 4-5; column 7, lines 11-14), including up to twelve pulsing steps (Figure 5).

8. As to claim 2, Tai discloses filling the etch system (110) with the first amount of the etchant (column 5, lines 42-45).

9. As to claim 3, Tai discloses filling the etch system (110) with the second amount of the etchant (column 5, lines 42-45; lines 53-55).

10. As to claim 4, Tai discloses that the first amount of etchant is fed during a first time slot of the first feeding cycle (column 7, lines 11-14); and wherein the second amount of etchant is fed during a second time slot (column 7, lines 11-14) of the second feeding cycle (column 6, lines 4-5; column 7, lines 11-14; Figure 1B).

11. As to claim 7, Tai discloses that the recipe comprises a spontaneous vapor phase etchant (column 3, lines 18-22); and wherein the amount of the etchant in the first amount of the etchant recipe equals the amount of the etchant in the second amount of the etchant recipe (column 5,lines 42-45; column 6, lines 4-5).

12. As to claim 8, Tai does not expressly disclose that the time interval between the provisions of the first amount of etchant recipe and the second amount of the recipe is predetermined. However, Tai disclose the series of steps involved, including the opening and closing of valves in order to introduce the spontaneous vapor phase etchant into etch chamber (110) (column 5, lines 54-67; column 6, lines 1-5) for a single pulse. Therefore, the time interval between the provisions of the first amount of etchant recipe and the second amount of the recipe is inherently predetermined.

13. As to claim 15, Tai discloses that the step of providing the first amount of etchant further comprises: (a) establishing a first pressure inside a first chamber (120) (column 4, lines 24-27), wherein the first pressure is equal to or lower than a pressure in a second chamber that contains a spontaneous vapor phase etchant (BrF_3 source, Figure 1A); (b) filling the first chamber (120) with an etchant (column 5, lines 42-45); (c) filling the first chamber (120) with a diluent gas such that the pressure inside the first chamber reaches a second pressure that is higher than the first pressure (column 4, lines 50-52); (d) circulating the etchant and the diluent gas through the etch chamber (column 5, lines 48-55).

14. As to claim 21, Tai discloses that the etchant recipe comprises a spontaneous vapor phase interhalogen (column 3, lines 18-22).

15. As to claim 24, Tai discloses that the etchant recipe comprises a diluent gas that is an inert gas (column 3, lines 18-22).

16. As to claim 25, Tai discloses that the inert gas is selected from N_2, He, Ar, Kr, and Xe (column 3, lines 18-22).

17. As to claim 26, Tai does not expressly disclose that the second chamber (120) has a temperature equal to or higher than the temperature of the first chamber (BrF_3 source). However, Tai's etching process occurs at room temperature (column 2, lines 8-12), and thus the second chamber (120) inherently has a temperature equal to or higher than the temperature of the first chamber (BrF_3 source).

18. As to claim 27, Tai does not expressly disclose that the temperature of the second chamber (BrF_3 source) is 25°C. However, Tai's etching process occurs at room

temperature (column 2, lines 8-12), and thus the temperature of the second chamber (BrF_3 source) is inherently 25°C.

19. As to claim 35, Tai discloses that the etchant has a pressure of 0.1 to 15 Torr (column 7, line 12; Figure 2).

20. As to claim 36, Tai discloses that the inert gas has a pressure from 20 to 700 Torr (column 8, lines 28-29).

21. As to claim 37, Tai discloses that the structural materials remain in the microstructure after the removal of the sacrificial material (column 7, lines 66-67; column 8, lines 1-4).

22. As to claim 38, Tai discloses that the structural materials comprise: a metal element, a metal alloy, a metal compound, a ceramic material or an anti-reflective film (column 8, lines 14-18).

23. As s to claim 43, Tai discloses that the ceramic material is selected from silicon nitride, silicon carbide, polysilicon, titanium nitride, titanium oxide(s), titanium carbide, $CoSi_xN_y$, $TiSi_xN_y$, and $TaSi_xN_y$ (column 8, lines 14-18).

24. As to claim 44, Tai discloses that the second amount of the etchant recipe is being circulated through the etch chamber (column 5, lines 48-55).

25. As to claim 45, Tai discloses that the step of providing the first amount of etchant further comprises: (a) establishing a first pressure inside a first chamber (120) (column 4, lines 24-27), wherein the first pressure is equal to or lower than a pressure in a second chamber that contains a spontaneous vapor phase etchant (BrF_3 source, Figure 1A); (b) filling the first chamber (120) with an etchant (column 5, lines 42-45); (c) filling

the first chamber (120) with a diluent gas such that the pressure inside the first chamber reaches a second pressure that is higher than the first pressure (column 4, lines 50-52); (d) circulating the etchant and the diluent gas through the etch chamber (column 5, lines 48-55).

26. As to claim 49, Tai discloses iterating an execution comprising the steps (a), (b), (c) and (d) a number of times (column 6, lines 4-5; column 7, lines 11-14; Figure 5).

27. As to claim 52, Tai discloses that the etchant recipe comprises a spontaneous vapor phase interhalogen (column 3, lines 18-22).

28. As to claim 55, Tai discloses that the etchant recipe comprises a diluent gas that is an inert gas (column 3, lines 18-22).

29. As to claim 56, Tai discloses that the inert gas is selected from N_2, He, Ar, Kr, and Xe (column 3, lines 18-22).

30. As to claim 57, Tai does not expressly disclose that the second chamber (120) has a temperature equal to or higher than the temperature of the first chamber (BrF_3 source). However, Tai's etching process occurs at room temperature (column 2, lines 8-12), and thus the second chamber (120) inherently has a temperature equal to or higher than the temperature of the first chamber (BrF_3 source).

31. As to claim 58, Tai does not expressly disclose that the temperature of the second chamber (BrF_3 source) is 25°C. However, Tai's etching process occurs at room temperature (column 2, lines 8-12), and thus the temperature of the second chamber (BrF_3 source) is inherently 25°C.

Claim Rejections - 35 USC § 103

32. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

33. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

34. Claims 5-6, 9,16-20, 29-32, 46-48, 50-51, and 60-63 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tai.

35. As to claim 5, Tai does not expressly disclose that the time interval between the first and second time slot does not equal the time interval of the first feeding cycle. However, Tai discloses that the time interval of the first feeding cycle can vary, between 20 seconds to 20 minutes (column 7, lines 13-14). Furthermore, Tai teaches, the reaction time is dependent on the number and size of the wafers being etched (column 5, lines 48-51). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step such that: the time interval

between the first and second time slot does not equal the time interval of the first feeding cycle. One who is skilled in the art would be motivated to allow the etching process proceed until it has been completed.

36. As to claim 6, Tai does not expressly disclose that the time interval of the first feeding cycle does not equal the time interval of the second feeding cycle. However, Tai discloses that the time interval of the first feeding cycle can vary, between 20 seconds to 20 minutes (column 7, lines 13-14). Furthermore, Tai teaches, the reaction time is dependent on the number and size of the wafers being etched (column 5, lines 48-51). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step such that: the time interval of the first feeding cycle does not equal the time interval of the second feeding cycle. One who is skilled in the art would be motivated to allow the etching process proceed until it has been completed.

37. As to claim 9, Tai does not expressly disclose providing a third amount of the etchant recipe during a third feeding cycle of the sequence of feeding cycles from removing the sacrificial material; and wherein the time interval between the provisions of the first amount and the second amount of the etchant does not equal the time interval between the provisions of the second amount of the etchant and the third amount of the etchant. Although Tai does not expressly disclose the step of providing a third amount of the etchant recipe during a third feeding cycle of the sequence of feeding cycles from removing the sacrificial material, this step is inherently present in Tai's method. Tai discloses that the amount of etchant gas is pulsed (column 6, lines 4-5; column 7, lines

11-14), including up to twelve pulsing steps (Figure 5). However, Tai discloses that when etching with the BrF_3 vapors, sufficient time must be given for all of the etchant to be consumed. Furthermore, Tai teaches, the reaction time is dependent on the number and size of the wafers being etched (column 5, lines 48-51). Tai also teaches that dilution of the etchant gas with xenon is important in obtaining uniform etching (column 4, lines 52-62). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step, such that: the time interval between the provisions of the first amount and the second amount of the etchant does not equal the time interval between the provisions of the second amount of the etchant and the third amount of the etchant. One who is skilled in the art would be motivated to allow the etching process proceed until it has been completed, including controlling the amount of diluent gas in order to obtain uniform etching.

38. As to claims 16 and 46, Tai does not expressly disclose establishing the second pressure inside the etch chamber by filling the etch chamber with the diluent gas before executing step (a). However, Tai discloses applying nitrogen gas to the etch chamber (110) to remove residual moisture and contaminants (column 6, lines 29-37). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include the step of: establishing the second pressure inside the etch chamber by filling the etch chamber with the diluent gas before executing step (a). One who is skilled in the art would be motivated to use xenon instead of nitrogen to reduce the number of processing steps during etching.

39. As to claims 17 and 47, Tai discloses that the step of (a) further comprises: maintaining the second pressure inside the etch chamber (column 6, lines 29-30).

40. As to claims 18 and 48, Tai discloses that the step of (b) further comprises: maintaining the second pressure inside the etch chamber (column 6, lines 29-30).

41. As to claims 19 and 50, Tai does not expressly disclose the etchant recipe comprises a spontaneous vapor phase noble gas halide. However, Tai teaches that xenon difluoride may be more expensive, it is also a suitable etchant for silicon micromachining (column 2, lines 55-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was to use an etchant recipe comprising of a spontaneous vapor phase noble gas halide. One who is skilled in the art would be motivated to use an alternative etchant that successfully accomplishes etching of silicon micromachined devices.

42. As to claim 20 and 51, Tai does not expressly disclose the etchant recipe comprises xenon difluoride. However, Tai that although xenon difluoride may be more expensive, it is also a suitable etchant for silicon micromachining (column 2, lines 55-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was to use an etchant recipe comprising xenon difluoride. One who is skilled in the art would be motivated to use an alternative etchant that successfully accomplishes etching of silicon micromachined devices.

43. As to claims 29 and 60, Tai does not expressly disclose that steps (a) through (d) are sequentially executed such that a total time of the sequential execution is from 7.5 seconds to 15 seconds. However, Tai discloses that when etching with the BrF_3

vapors, sufficient time must be given for all of the etchant to be consumed. Furthermore, Tai teaches, the reaction time is dependent on the number and size of the wafers being etched (column 5, lines 48-51). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step, such that: steps (a) through (d) are sequentially executed such that a total time of the sequential execution is from 7.5 seconds to 15 seconds. One who is skilled in the art would be motivated to allow the etching process proceed until it has been completed.

44. As to claims 30 and 61, Tai does not expressly disclose that step (a) is executed for a time from 100 to 1500 milliseconds. However, Tai discloses that when etching with the BrF_3 vapors, sufficient time must be given for all of the etchant to be consumed. Furthermore, Tai teaches, the reaction time is dependent on the number and size of the wafers being etched (column 5, lines 48-51). Tai also teaches that dilution of the etchant gas with xenon is important in obtaining uniform etching (column 4, lines 52-62). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step, such that: that step (a) is executed for a time from 100 to 1500 milliseconds. One who is skilled in the art would be motivated to allow the etching process proceed until it has been completed, including controlling the amount of diluent gas in order to obtain uniform etching.

45. As to claims 31 and 62, Tai does not expressly disclose that step (b) is executed for a time around 500 milliseconds. However, Tai discloses that when etching with the BrF_3 vapors, sufficient time must be given for all of the etchant to be consumed. Furthermore, Tai teaches, the reaction time is dependent on the number and size of the

wafers being etched (column 5, lines 48-51). Tai also teaches that dilution of the etchant gas with xenon is important in obtaining uniform etching (column 4, lines 52-62). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step, such that: that step (b) is executed for a time around 500 milliseconds. One who is skilled in the art would be motivated to allow the etching process proceed until it has been completed, including controlling the amount of diluent gas in order to obtain uniform etching.

46. As to claims 32 and 63, Tai does not expressly disclose that step (c) is executed for a time from 1000 to 3000 milliseconds. However, Tai discloses that when etching with the BrF_3 vapors, sufficient time must be given for all of the etchant to be consumed. Furthermore, Tai teaches, the reaction time is dependent on the number and size of the wafers being etched (column 5, lines 48-51). Tai also teaches that dilution of the etchant gas with xenon is important in obtaining uniform etching (column 4, lines 52-62). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step, such that: that step (c) is executed for a time from 1000 to 3000 milliseconds. One who is skilled in the art would be motivated to allow the etching process proceed until it has been completed, including controlling the amount of diluent gas in order to obtain uniform etching.

47. Claims 10-14, 28, 33, 39-42, 59, and 64-70 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tai, in view of Wolf, *Silicon Processing for the VLSI Era*, Vols. 1 and 4, Lattice Press (1986, 2002).

48. As to claim 10, Tai does not expressly disclose determining whether the amount of the sacrificial material inside the etch chamber is below a predetermined value. Wolf teaches that diagnostic monitoring for end point detection is important to prevent overetching (vol. 1, page 565). One method for end point detection is gas phase measurements, which have the ability to provide real-time chemical information about the chamber during the etching process, such as etch products. Furthermore, the end point is triggered when the concentration of an etch product reaches a preset level (vol. 1, page 567). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include the step of: determining whether the amount of the sacrificial material inside the etch chamber is below a predetermined value. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

49. As to claim 11, Tai does not expressly disclose that the predetermined value is 1% of the total amount of the sacrificial materials before etching. In light of Wolf's teachings regarding end point detection, it would have been obvious to one of ordinary skill in the art at the time the invention was made to: select a predetermined value 1% of the total amount of the sacrificial materials before etching. One who is skilled in the art would be motivated to select a predetermined value dependant on the final microstructure and to prevent overetching.

50. As to claim 12, Tai does not expressly disclose dynamically detecting the concentration of an etch product; and comparing the detected concentration to a predetermined value. In light of Wolf's teachings regarding end point detection, it would

have been obvious to one of ordinary skill in the art to include the steps of: disclose dynamically detecting the concentration of an etch product; and comparing the detected concentration to a predetermined value. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

51. As to claim 13, Tai does not expressly disclose that if a change of the detected concentration over a unit time is lower than the predetermined value, stopping the etching process. In light of Wolf's teachings regarding end point detection, it would have been obvious to one of ordinary skill in the art at the time the invention was made to: include the step such that if a change of the detected concentration over a unit time is lower than the predetermined value, stopping the etching process. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

52. As to claim 14, Tai does not expressly disclose that if a change of the detected concentration over time is equal to or lower than the predetermined value, feeding the second amount of etchant into the etch chamber. In light of Wolf's teachings, it would have been obvious to one of ordinary skill in the art at the time the invention was made to: include the step such that if a change of the detected concentration over time is equal to or lower than the predetermined value, feeding the second amount of ethant into the etch chamber. One who is skilled in the art would be motivated to continue the etching process if the etching step has not been completed.

53. As to claims 28 and 59, Tai does not expressly disclose that the second chamber has a cubical volume equal to or less than one twentieth of a cubical volume of the etch chamber. However, Tai discloses that the size of second chamber (120) is 320 cm^3 and

the size of etch chamber (110) is 1990 cm^3, selected to accommodate ten 4-inch wafers. Tai also teaches that the size both chambers can be modified to accommodate the amount and size of the wafers to be processed (column 4, lines 24-32). Wolf teaches that processing semiconductors on 300-mm wafers is more economical, because the benefits of additional processing area coupled with the constant cost of manufacturing silicon wafers (vol. 4, pages 66-67). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select chambers such that: that the second chamber has a cubical volume equal to or less than one twentieth of a cubical volume of the etch chamber. One who is skilled in the art would be motivated to increase the size of the etch chamber relative to the second chamber to accommodate larger wafers.

54. As to claim 33 and 64, Tai does not expressly disclose the step of breakthrough etching the sample before establishing the second pressure inside the etch chamber. Wolf teaches that scrupulously cleaned wafers are critical in order to obtain high yields for semiconductor processing (vol. 1, page 514), including the removal of native oxide from silicon (vol. 1, page 520). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include the step of: breakthrough etching the sample before establishing the second pressure inside the etch chamber. One who is skilled in the art would be motivated to maintain scrupulously cleaned wafers for high process yields.

55. As to claim 39, Tai does not expressly disclose that the metal element is selected from Al, Ir, Ti, Ag, W, Ta and Mo. Wolf teaches that Al is commonly used to fabricate

semiconductor components due to its low resistivity and compatibility with silicon and silicon oxide (vol.1, page 332). Wolf further teaches that for higher-temperature processing, low resistivity refractory metals (W, Ti, Mo, and Ta) are used (vol. 1, page 399). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use a metal element is selected from Al, Ir, Ti, Ag, W, Ta and Mo. One who is skilled in the art would be motivated to select a material with low resistivity compatible with semiconductor processing.

56. As to claim 40, Tai does not expressly disclose that the metal alloy is selected from WTi_x, WMo_x, WTa_x. Wolf further teaches that for semiconductor devices that require higher-temperature processing, low resistivity refractory metals (W, Ti, Mo, and Ta) are used (vol. 1, page 399). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select a metal alloy from WTi_x, WMo_x, WTa_x. One who is skilled in the art would be motivated to select a material with low resistivity compatible with semiconductor processing.

57. As to claim 41, Tai does not expressly disclose that the metal compound is selected from WAl_x, $AlTi_x$, and metal silicide. Wolf teaches that Al is commonly used to fabricate semiconductor components due to its low resistivity and compatibility with silicon and silicon oxide (vol. 1, page 332). For more elaborate contact structures, Al is alloyed with Cu, Si, Ti, and W (vol. 1, pages 332-33). Wolf also teaches that silicides are a commonly used material, due to low resistivity, which reduces interconnect delay (vol. 1, page 386). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use a metal compound selected from WAl_x,

$AlTi_x$, and metal silicide. One who is skilled in the art would be motivated to select a material with low resistivity compatible with semiconductor processing.

58. As to claim 42, Tai does not expressly disclose that the metal silicide is selected from $AlSi_x$, WSi_x, $MoSi_x$, $TiSi_x$, $ZrSi_x$, $CrSi_x$, $TaSi_x$, $AlSi_xCu_y$, TiW_xSi_y. Wolf teaches that $TiSi_2$, $TaSi_2$, $MoSi_2$, WSi_2, and PtSi (vol. 1, page 386, Table 2) are commonly used silicides, because they can withstand higher processing temperatures. Furthermore, Wolf teaches, resistivity is the key parameter of a silicide that reduces interconnect delay (vol. 1, page 386). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use a metal silicide selected from $AlSi_x$, WSi_x, $MoSi_x$, $TiSi_x$, $ZrSi_x$, $CrSi_x$, $TaSi_x$, $AlSi_xCu_y$, TiW_xSi_y. One who is skilled in the art would be motivated to select a silicide material, compatible with semiconductor processing in order to reduce interconnect delay in the device.

59. As to claim 65, Tai discloses performing a first iteration of the execution comprising of steps (a) through (d) (column 6, lines 4-5; column 7, lines 11-14; Figure 5). Tai does not expressly disclose: detecting a status of a chemical species flowing out from the etch chamber; and performing a second iteration of the execution comprising of steps (a) through (d) after the first iteration depending upon the detected status of the chemical species. Wolf teaches that diagnostic monitoring for end point detection is important to prevent overetching (vol. 1, page 565). One method for end point detection is gas phase measurements, which have the ability to provide real-time chemical information about the chamber during the etching process, such as etch products. Furthermore, the end point is triggered when the concentration of an etch

product reaches a preset level (vol. 1, page 567). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include the steps of: detecting a status of a chemical species flowing out from the etch chamber; and performing a second iteration of the execution comprising of steps (a) through (d) after the first iteration depending upon the detected status of the chemical species. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

60. As to claim 66, Tai does not expressly disclose that the status of the chemical species is the mole mass. However, Wolf teaches that mass spectroscopy is a gas phase measurement technique for end point detection. Mass spectroscopy operates by removing gas species, rather than data from a plasma emission (vol. 1, page 567). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to select an end point detection technique such that: the status of the chemical species is the mole mass. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

61. As to claim 67, Tai does not expressly disclose stopping etching the microstructure when the status of the status of the chemical species reaches a predetermined value. In light of Wolf's teachings regarding end point detection, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include the step of: stopping etching the microstructure when the status of the status of the chemical species reaches a predetermined value. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

62. As to claim 68, Tai does not expressly disclose that the status of the chemical species is the etching rate. In light of Wolf's teachings regarding end point detection, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include a step such that: the status of the chemical species is the etching rate. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

63. As to claim 69, Tai does not expressly disclose that the predetermined value is 1% or less. In light of Wolf's teachings regarding end point detection, it would have been obvious to one of ordinary skill in the art at the time the invention was made such that: the predetermined value is 1% or less. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

64. As to claim 70, Tai does not expressly disclose that the chemical species is selected from SiF, SiF_3 and SiF_4. Wolf teaches that one of the chemical species detected for end point detection is SiF (vol. 1, page 566, Table 3). Wolf also teaches that mass spectroscopy is a gas phase measurement technique for end point detection. Mass spectroscopy operates by removing gas species, rather than data from a plasma emission (vol. 4, page 567). In light of Wolf's teachings regarding end point detection, it would have been obvious to one of ordinary skill in the art at the time the invention was made such that: the chemical species is selected from SiF, SiF_3 and SiF_4. One who is skilled in the art would be motivated to prevent overetching of the microstructure.

65. Claim 22 and 53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tai, in view of Rossnagel et al., *Handbook of Plasma Processing*, Noyes Publications (1990).

66. As to claims 22 and 53, Tai does not expressly disclose that the interhalogen comprises bromine trichloride. However, Tai discloses that bromine trifluoride is the spontaneous vapor phase etchant (column 3, lines 18-22). Furthermore, Rossnegal teaches that the plasma etching of silicon can be accomplished with fluorine, chlorine, or bromide-based chemistries (pages 200-201). Although applicant discloses vapor phase etching, similar results for silicon etching with fluorine, chlorine, or bromide-based chemistries would be expected. Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to etch with bromine trichloride. One who is skilled in the art would use motivate to use a gas chemistry which is known to accomplish silicon etching.

67. Claims 23 and 54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tai in view of Han et al. (U.S. Patent No. 6,740,247).

68. As to claim 23 and 54, Tai does not expressly disclose that the etchant recipe comprises a spontaneous vapor phase HF. Han teaches that the cleaning of silicon substrates is critical in microelectronic fabrication (column 1, lines 17-23), including the removal of oxides and other contamination (column 1, lines 27-33). Han further teaches that HF vapor phase etching is highly efficient, precise, and reproducible (column 4, lines 13-19) when the monolayer coverage is controlled (column 3, lines 12-15). Therefore, it would have been obvious to one of ordinary skill in the art at the time the

invention was made to use an etchant recipe that comprises a spontaneous vapor phase HF. One who is skilled in the art would be motivated to use a highly efficient, precise, and reproducible method of cleaning silicon wafers.

69. Claims 34 and 71 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tai in view of Ashurst et al., *Journal of Microelectromechanical Systems*, Vol. 10, No. 1 (March 2001).

70. As to claims 34 and 71, Tai does not expressly disclose coating the sample with a SAM material. However, Tai discloses a method for gas phase etching of microelectromechanical systems (MEMS) (column 1, lines 10-12). Ashurst teaches that a common mode of failure for MEMS is the adhesion of adjacent surfaces or stiction. Ashurst further teaches forming self-assembled monolayers on the silicon microstructure to alleviate adhesion-related problems (page 41). Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to include the step of: coating the sample with a SAM material. One who is skilled in the art would be motivated to prevent striction, a common failure mechanism for MEMS.

Allowable Subject Matter

71. Claims 72-91 are allowed. The following is an examiner's statement of reasons for allowance: the prior art fails to teach or suggest circulating a first amount of spontaneous vapor phase etchant recipe via a first loop that passes through the etch chamber for removing the sacrificial material, as in the context of claim 72. The closest prior art, Tai, teaches: loading a microstructure (column 6, lines 59-60) into an etch

chamber (110) (column 6, line 29), wherein the microstructure comprises a sacrificial material (column 6, lines 64-67) and one or more structural materials (column 6, line 29). However, there is no motivation or suggestion of circulating a first amount of spontaneous vapor phase etchant recipe via a first loop that passes through the etch chamber for removing the sacrificial material, as in the context of claim 72.

72. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

73. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Cook et al. (U.S. Patent No. 4,498,953) discloses a vapor phase etching method for silicon using halogen fluorides. Becker et al. (U.S. Patent No. 6,558,559) discloses a vapor phase etching method for a sacrificial material on a silicon substrate. Tai et al. (U.S. Patent No. 6,436,229) discloses a bromine trifluoride vapor-phase etching method for silicon.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Eric B. Chen whose telephone number is (571) 272-2947. The examiner can normally be reached on Monday through Friday, 8AM to 4:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine G. Norton can be reached on (571) 272-1465. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

LAN VINH
PRIMARY EXAMINER

EBC EBC
Feb. 17, 2005